

Analysis on the influence of supply method on a workstation with the help of dynamic simulation

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Abstract. Considering the need of flexibility in any manufacturing process, the choice of the supply method of an assembly workstation can be a decision with instead influence on its performances. Using dynamic simulation, this article wants to compare the effect on a workstation cycle time of three different supply methods: supply on stock, supply in “Strike Zone” and synchronous supply. This study is part of an extended work that has the aim of compering by 3D layout design and dynamic simulation, different supply methods on an assembly line performances.

1 Introduction

By Blackstone and Cox [1], an assembly line is an assembly process where the equipment and the workstations are so arranged that the sequence of assembly is followed.

A workstation is the place where the processes of assembly have place. It is defined by a precise area and contains known tasks. The parts that have to be assembled need a entire sequence of operation in the workstation [2]. In an assembly line, the method of supply with parts is of great importance, it represents one of the basics of the performance of the system and also makes a transition between two different processes: logistic and assembly operations.

The supply of an assembly line represents the transport of components needed for each workstation where the products are assembled. The supply must consider two main actions: to ensure the needed quantity and to ensure all the types of components (diversity) for all types of products. There are more types of supply methods: supply based on stock, supply in Strike Zone and synchronous supply.

The supply on stock is the most often met. Wänström and Medbo [3] say that in this type of supply the parts are placed in storage inside the assembly line. The parts stocks are refilled periodically after they are depleted. Caputo and Pelagagge [4] considering that comparing to other methods of supply of type JIT, this type is one discontinuous. It is considered that this method increases the effort of the operator due to the parts handling and makes it harder for him to search for the needed components.

The supply in Strike Zone means a reorganization of the workstation and its supply, allowing the operator to concentrate only on the tasks of assembly process, reducing the

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wasted time with the movement to choose parts. The operators' activities can be more focused on ensuring the quality of its work. To do that, the operator can receive the needed parts in a rack or on conveyers that are placed on the side or in front of the operator, in an optimum ergonomic area, known as Strike Zone. This is easier to use with an integrated management system of the assembly line which makes the link between the production program and the flow of supply.

The synchronous supply can be used only if exists an integrated management system of the assembly line. The information taken from this system are used to synchronize the flows of supply with the flow of production, the parts arrive in the workstation exactly in the moment and order they are needed.

The simulation is the process of creating a model after a real life system (existing or in design phase) and making a series of experiments on it, with the purpose of understanding its behavior and to evaluate new optimization strategies. The simulation means the representation of a system or a phenomenon, basing on a model that allows the analysis of its characteristics and its distinct behavior in different hypothetical situations [5].

With the help of simulation the researcher can generate scenarios that in real life can't be observed and more importantly is the possibility to test conditions and scenarios before implementing them, reducing considerably the costs and the degree of risk taken. Also another strong advantage of the simulation is that it gives a better understanding of the complex interaction of certain variation factors and the interdependency between them. The results are more as tendencies and help to formulate or test analytical expressions.

The dynamic simulation, next to the layout design, is the main tool used in this study and analysis of the methods of supply of the production system.

2 Research methodology

At the base of the dynamic simulation study is the functional model. This modelling method was used to explain the methodology of simulation study, Figure 1:

- A41 – Dynamic simulation model construction: using the functional model and the results of layout design, the model that mimics the real life system is built. The model must copy the real life operating mode and has to include the variations that will give the "randomness" specific to real life situations. This model is further transferred to validation

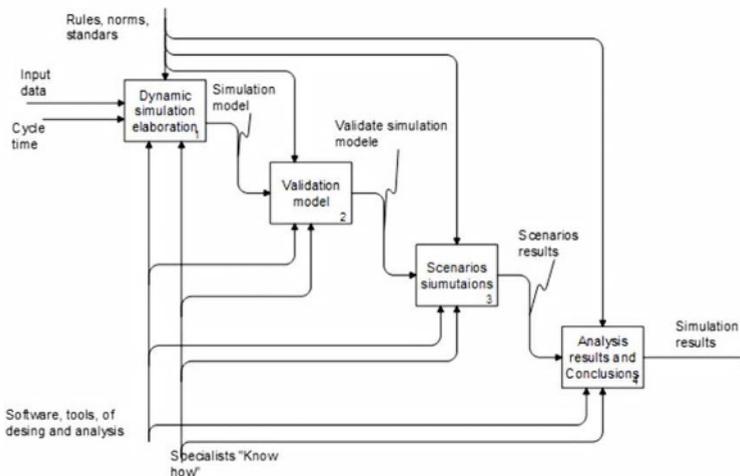


Fig.1. Dynamic simulation study.

step;

- A42 – Model validation: has as aim to ensure the correctitude of the simulation model from operation point of view and variable interdependence. The best way to validate is to compare with a real life reference scenario. The result is a valid model that will be used in scenarios simulation.
- A43 – Scenarios simulation: starting from the validated model, the designer has to implement all the foreseen scenarios exiting performance results as system capacity, efficiency, OEE etc.
- A44 – Analysis of results and conclusions: considering the art of dynamic simulation, this step is the most challenging. Starting from scenarios results, the designer has to make conclusions and to detect bottlenecks or tendencies.

As entry data, the model has the input that is common with layout design, and data that come from the analysis of the layout.

By analysing this input, the designer has to separate events that are common for each cycle time and events that appear with a frequency. This frequency can be variable, as a workstation breakdown or exterior perturbation, or invariable, as packaging change when it gets empty or programed tools changes or preventive maintenance.

Another factor that generates events is the setup time at batch change. This can be of two types: setup time due to process (tools change, program change etc.), or setup time due to workstation supply (change of packaging, change of parts location etc.).

In Figure 2, are represented as events the setup time at batch change and the change of packaging when empty.

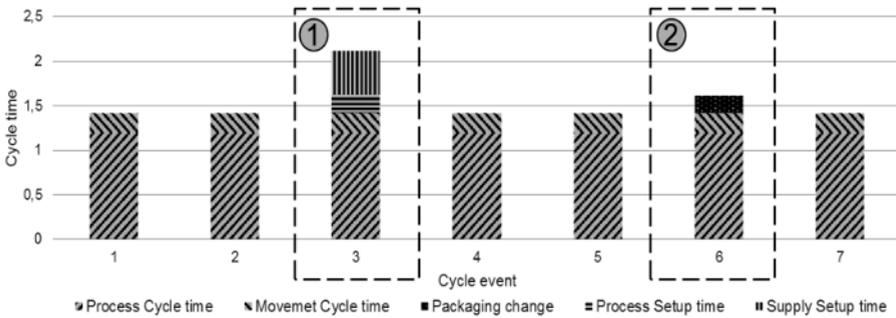


Fig.2. Example of events that appear in the workstations (cycle time in minutes).

The events have constant frequency and variable frequency. The dispersion of the variables must be determined or chosen from the research literature, according to its specificity.

An example can be the triangularvariable distribution. This distribution expression is used frequently to represent the variation of manual activities. Considering a mean manual cycle time of 0.224min., a dispersion of the variable can be $\pm 10\%$. This dispersion copies the accepted variation of an operator manual cycle time that has a normal degree of dexterity.

Other variables must be determined by analysing the historic of events and extracting a low that represents them. As example, the logistic system doesn't always give the right quantity of parts at the needed moment, so the workstation can have stoppagesdelays due to lack of parts.

3 Application of methodology on a given case

3.1 Workstation supply and cycle time impact

Starting from the influence of the supply method on the workstation, Figure 3, each configuration has to be converted in time influence.

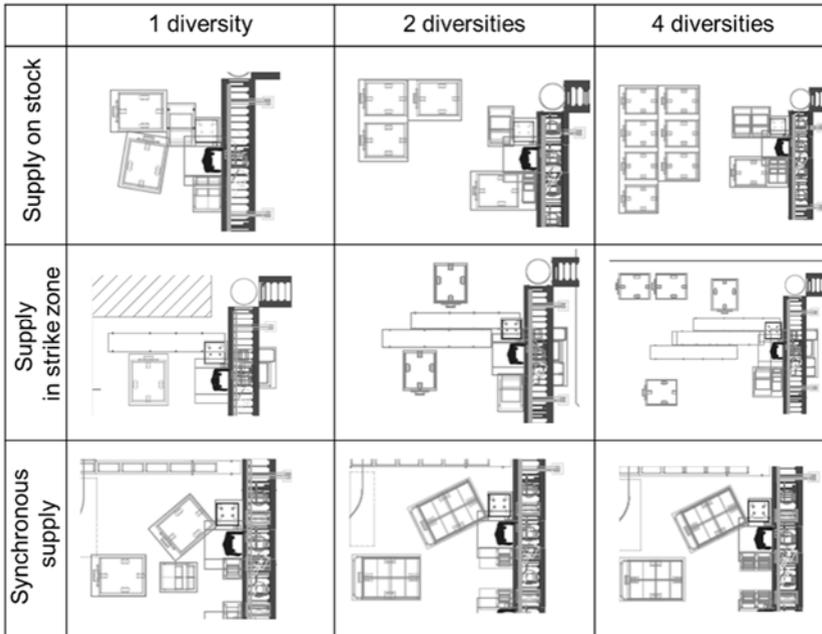


Fig.3. Different workstation configuration, depending on the supply method.

Considering the process cycle time a variable not influenced by the method of supply, this will be the same in all the simulation scenarios.

The operator movement differs from one configuration to another. In the case of supply on stock the operator receives the parts directly from logistic storage area. There are no other handling operations on the flow. In the case of strike zone supply, the parts are loaded on the supply conveyors and racks that transport the parts more concentrated in the working area. For the synchronous supply, the parts are sequenced in a preparation area (picking, kitting), this operation adding one more handling on the flow.

The impact of the layout on the cycle time is presented in the table 1. We can observe there that for the supply on stock, beside the cycle time, the workstation has a setup time due to workstation rearrangement.

In Strike Zone, beside the workstation cycle time, appears the operation of preparation with its on time added. For synchronous supply, the sequencing also means a handling that also comes with a time impact. All this time added to the end product will be included in the dynamic model and will be transposed in influence on production and costs.

Beside this durations, the model also includes the random generated events like: breakdown or external influences.

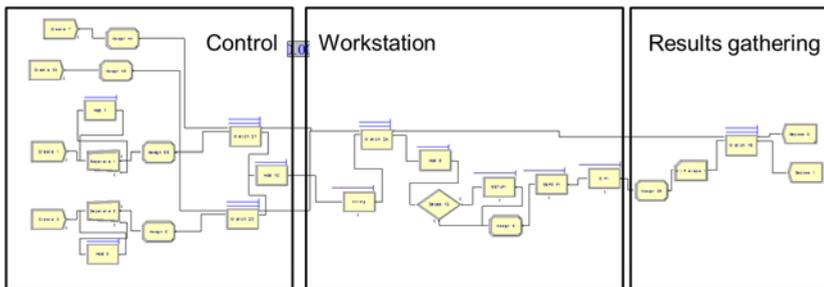
A factor that is not taken into account is the link of the workstation with the other workstations, cause of the limit of the analysed perimeter.

Table 1. Sequence of operations impact in operator movements.

Supply method	Workstation (cycle time impact - min.)			
	Product diversity	1	2	4
On stock	Workstation	1,424	1,424	1,540
	Preparation	-	-	-
	Setup	-	0,192	0,224
In Strike Zone	Workstation	1,232	1,25	1,27
	Preparation	0,064	0,064	0,096
	Setup	-	-	-
Synchronous	Workstation	1,344	1,36	1,36
	Preparation	-	-	-
	Setup	-	-	-
	Kitting	0,098	0,197	0,296
	Picking		0,138	0,194

3.2 Dynamic simulation model

Starting from the functional modeling of the industrial system, it is built a dynamic model. To simplify the work and scenarios implementation, the model is as simple as possible, and complex enough to take into account all the considered influences on the final parameters, Figure 4.

**Fig.4.** The dynamic simulation model

As for this model, there are 3 distinct sub-models: control, workstation and results gathering.

The control module is responsible of: order analysis, production grouping and attributes allocation. This module also manages the system conduction a pull or push type system, a certain flow or another depending of the type of supply. The workstation module is the one that mimics the operating mode of the workstation and its characteristics as: setup at product change, workstation supply, and the logistic preparation stage. The result gathering module defines and gathers the results as needed for analysis.

To compare the 3 types of supply methods it were considered a set of scenarios varying the number of products manufactured on the line. To compare the 3 hypotheses of supply and the impact of diversity, it was used the production per hour and the cost per part (due to the operations of process and handling). The results are shown in Figure 5.

If we consider the production per hour we can observe that the higher production is at the workstation supplied in strike zone. Also this type of supply is the most stable at variation of number of products. The synchronous supply is the second most productive supply method and on this area of variation of number of products has also a stable reactivity. The supply on stock has the lowest productivity and it is seen a strong decrease at the increase of number of products (more than 7% decrease from 1 diversity to 4 diversities).

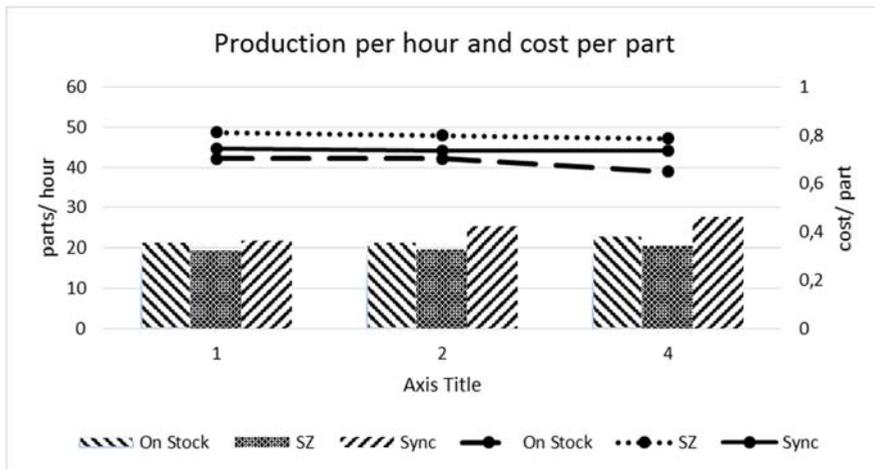


Fig.5. Results of simulation in: production per hour and cost per part.

Considering the cost per product it can be observed that the lowest cost also for the supply on strike zone. Also the increase of cost on this type of supply is of only 5%. The second least costly type of supply is the supply on stock with a cost increase at number of products variation of 8%. The most costly supply is the sequenced supply. Also the increase of number of products leads to an increase of 28% of cost.

4 Conclusions

The conclusions of this layout and dynamic simulation model are very important, mostly because the results are contra intuitive. Considering more than one factor of influence and including a larger view of the subject can only increase the correctness of the conclusions of the studies.

As example, considering the number of handlings on the flow, it could be concluded that the less costly is the supply on stock, but due to the high impact of the layout (operator movement), the production decreases, and the cost per unit increases. Also it can be seen that two methods of supply by a logistic preparation area (strike zone and synchronous) have different impact on production and cost.

The next step to make, in order to have a better result is to build all the industrial system (workstations, logistic preparation areas and also to include de movement of the logistic operators). Gathering all this data and transposing them in the dynamic model we will have an overall impact of the supply method.

Another conclusion is that we can observe that it doesn't exist a solution valid in all cases. What the designer can do is to construct a flexible system, which can be easily adapted to variations and can be easily changed in case of need.

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